REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	30 Nov 1997	Final (01 Jul 94 – 30 Jun 97)

4. TITLE AND SUBTITLE
The Application of Broadband Arrays and Networks to Seismic Monitoring of Uncalibrated Regions

5. FUNDING NUMBERS
F49620-94-0271

6. AUTHORS
Professor Thomas J. Owens

AFRL-SR-BL-TR-98-
0215

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of South Carolina
Columbia, SC 29208

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NM
110 Duncan Avenue, Room B-115
Bolling Air Force Base, DC 20332-8080

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for Public Release

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Lg results have clarified a long-standing debate about the cause of Lg blockage by the Tibetan Plateau. Understanding the nature of this blockage is critical to understanding the effect it has on common discriminants that utilize Lg. The unusual propagation characteristics of Sn also lead to anomalous waveforms that need to be understood before regional waveforms from this area can be confidently used for seismic monitoring measurements. Continuing regional waveform modeling has led to a better understanding of north-south variations in mantle structure and the effects these variations have on regional waveforms. The effect of event mislocation on derived layered velocity models in the Tibetan Plateau have been quantified better. In addition, using the derived sources and structural information, common discriminant measurements for many regional events in the plateau will be compiled to better document the influence the unusual regional structure may have on event discrimination in Central Asia. The determination of a local magnitude scale for events recorded by the 1991-92 Tibetan Plateau seismic experiment has been completed. This analysis suggests that there is a distance bias that underestimates magnitudes for station-event separations of more than 600km. This may be related to the increased attenuation of Lg at similar distances that we observed in our Lg analysis.

14. SUBJECT TERMS
Lg, Tibetan Plateau, Sn

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

Contract #F49620-94-1-0271

AASERT AUGMENTATION TO:

THE APPLICATION OF BROADBAND ARRAYS AND NETWORKS TO SEISMIC MONITORING OF UNCALIBRATED REGIONS

Parent Agreement: Contract #F49620-94-1-0066DEF

Thomas J. Owens
Department of Geological Sciences
University of South Carolina
Columbia, South Carolina 29208

30 November 1997

Final Technical Report for Period: 1 July 1994 - 30 June 1997

Prepared for:

Air Force Office of Scientific Research/NM
Suite B115
110 Duncan Avenue
Bolling AFB, DC 20332-8080

RESEARCH OBJECTIVES

One approach to calibrating areas of nonproliferation concerns is the use of mobile arrays of new generation, high dynamic range, broadband digital seismic instruments. This project uses existing data from a variety of seismic deployments to assess the utility of this approach and to develop strategies for using temporary deployments to gather data to address seismic monitoring concerns. We will use data from deployments in Turkmenistan, Kyrgyzia, and the Tibetan Plateau that span a wide range of scales with minimum station spacings of 0.150 to 100 km over array dimensions of 2 to 1500 km.

The broad areas of research are: I) Characterization of lithospheric heterogeneities through analysis of broadband "dense" array data; II) Regional source and structure studies using closely spaced broadband stations; and III) Detection, location, and discrimination studies to evaluate both the utility of temporary deployments and build background observations for Central Asia and the Middle East. The application of the methods we propose to a variety of data sets allows us to both characterize multiple regions and assess the portability of these methods.

STATEMENT OF WORK - PARENT AGREEMENT

Task I - Characterization of Lithospheric Heterogeneities

- Multi-dimensional signal processing to characterize lithospheric heterogeneity and determine their effect on broadband waveforms using the Alibek and PFO dense arrays.

Task II - Regional Source and Structure Studies

- Evaluation of combined source and structure modeling approaches using the Tibetan Plateau dataset.

- Application of preferred methodology to source and structure studies using regional events recorded by Alibek, KNET, and Tibet stations.

- Assessment of the affects of complex structure on regional waveforms using Tibet, CDSN, and KNET data.

Task III - Detection, Location, and Discrimination in Uncalibrated Regions

- Regional broadband 3-component dense array detection and discrimination studies using Alibek and PFO data.

- Compilation of common seismic discriminant measurements for Central Asia and Middle East seismicity using data recorded by Alibek, KNET, and Tibet stations.

SUMMARY OF EFFORT

Temporary broadband networks are clearly an advantage to efforts to calibrate relatively unknown regions. Our results demonstrate the type of information that can be determined with this type of data. Students have participated in this effort supported by both the Parent Agreement and the AASERT supplement. AASERT funding has been the primary support for Ph.D. student Philip Crotwell, who is working on the Sn propagation studies outlined below. The discrimination studies have been the focus of research by MS student Mark Powers, supported on the Parent Agreement. The Lg study was undertaken by Ph.D. student Dan McNamara with salary support from other sources, but computing, travel and publication support from the Parent Agreement. Our Lg results have clarified a long-standing debate about the cause of Lg blockage by the Tibetan Plateau. Understanding the nature of this blockage is critical to understanding the effect it has on common discriminants that utilize Lg. The unusual propagation characteristics of Sn also lead to anomalous waveforms that need to be understood before regional waveforms from this area can be confidently used for seismic monitoring measurements. Continuing regional waveform modeling has led to a better understanding of north-south variations in mantle structure and the effects these variations have on regional waveforms. We have also been able to better quantify the effect of event mislocation on derived layered velocity models in the Tibetan Plateau. In addition, using the sources and structural information derived in our work, we will be compiling common discriminant measurements for many regional events in the plateau to better document the influence the unusual regional structure may have on event discrimination in Central Asia. We have completed the determination of a local magnitude scale for events recorded by the 1991-92 Tibetan Plateau seismic experiment. This analysis suggests that there is a distance bias that underestimates magnitudes for station-event separations of more than 600km. This may be related to the increased attentuation of Lg at similar distances that we observed in our Lg analysis.

ACCOMPLISHMENTS

TASK I -- Characterization of Lithospheric Heterogeneity

No students supported under this task, progress is summarized in the Parent Agreement Report.

TASK II - Regional Source and Structure Studies

In this section, we only summarize the status of the work by Philip Crotwell, who received support during the reporting period through the AASERT supplement.

The Tibetan Plateau is a dominant structural feature influencing seismic wave propagation in Central Asia. Using data from the 1991-92 Tibetan Plateau Seismic Experiment deployment of broad-band PASSCAL sensors, we are studying the effects of the Tibetan Plateau on a variety of regional phases propagating within the plateau and crossing its boundaries. Examples of specific studies undertaken under this contract include a study of Lg propagation in the Tibetan Plateau (McNamara et al, 1995) and an ongoing analysis of broadband Sn propagation (Crotwell et al., 1995; Owens et al, 1995).

Crotwell's study involves waveform modeling of Pn and Sn waveforms from regional events of moderate magnitude. Source mechanisms for these events have been recently published, providing the necessary constraints to begin detailed structural modeling. It has been known for a decade that there are significant lateral variations in Sn propagation within the plateau, specifically that the central northern Tibetan Plateau blocks the propagation of high-frequency Sn phases. Using broadband regional seismograms from events within the plateau, we document that this blockage is strongly frequency-dependent. The available station spacing allows us to observe a rapid loss of high frequencies as regional S phases cross into the northern plateau while frequencies below 0.05Hz propagate throughout the plateau. Variations in the displacement pulse-shapes through the transition into the northern plateau are more easily explained by a changes in Poisson's ratio with depth than by simply rapid changes in the attenuation structure.

The propagation and attenuation characteristics of Lg are used to document that Lg can propagate within the thickened crust of the Tibetan Plateau and to confirm previous studies showing that all boundaries of the plateau are effective barriers to Lg propagation. Our results further indicate that attenuation of Lg within the plateau is relatively high, comparable to areas of active tectonics, such as the Basin and Range Province.

TASK III -- Detection, Location, and Discrimination in Uncalibrated Regions

In an effort to evaluate regional source discriminants for the plateau, we have developed a local magnitude scale to use in the ML:Mo discriminant. We first evaluate station-network ML residuals for 82 regional events using broadband seismograms from the 1991-92 experiment corrected to a Wood-Anderson response. Initial analysis indicates that rapid attenuation of regional Lg at distances beyond 600 km is evident in the amplitude terms and may bias magnitude estimates at these distances.

Using this work as a guide, we have relocated 80-100 small events from the Tibetan Plateau deployment and calculated magnitudes for these events. This exercise will give us a feel for the detection threshold of both the global PDE catalog and a regional network such as the Tibetan Plateau network. Mark Powers has completed much of this study and will be defending his MS thesis in early 1998.

PERSONNEL SUPPORTED

Principal Investigator: Thomas J. Owens [No support under AASERT]

Graduate Students: H. Philip Crotwell, Ph.D. Student (via AASERT)
Daniel E. McNamara, Ph.D. Student (no direct salary support)
Mark R. Powers, M.S. Student (via Parent Agreement and AASERT)
Arleen A. Hill, M.S. Student (via Parent Agreement and AASERT)

REFEREED PUBLICATIONS by Students

McNamara, D. E., T. J. Owens, and W. R. Walter, Propagation Characteristics of Lg Across the Tibetan Plateau, Bull. Seism. Soc. Am., 85, 457-469, 1996

McNamara, D.E., W.R. Walter, T.J. Owens, and C.J. Ammon, Upper mantle velocity structure beneath the Tibetan Plateau from Pn travel time tomography, J. Geophys. Res., 102, 493-506, 1997.

TECHNICAL REPORTS with Student Participation

Crotwell, H.P., M.R. Powers, T.J. Owens, and G. Zandt, Characterization of seismic structure and wave propagation within the Tibetan Plateau, *Proceedings of the 18th Annual Research Symposium on Monitoring a Comprehensive Test Ban Treaty, Annapolis, MD,* September 1996.

Owens, T.J., H.P. Crotwell, D.E. McNamara, and G.E. Randall, Regional Wave Propagation in and around the Tibetan Plateau, *Proceedings of the 17th Annual Research Symposium on CTBT Monitoring, Scottsdale, AZ,* September 1995.

INTERACTIONS/TRANSITION ACTIVITIES

Meetings and Conferences

Crotwell, H.P., G.E. Randall, D.E. McNamara, and T.J. Owens, Frequency-dependent propagation of regional Sn within the Tibetan Plateau, *EOS, Trans. Am. Geophys. Un., Spring Meetings Supplement, 1995.*

Crotwell, Power, and Hill participated in several IRIS and AFOSR workshops.

Transitions with Other Laboratories

This project benefits from good working relationships with the Seismic Monitoring groups at Lawrence Livermore and Los Alamos National Laboratories. The reflectivity code used in Task II was developed by G. Randall under internal USC funding and LLNL funding to USC. We benefit from the work of Howard Patton of LLNL who helped implement the parallel version of the code now in use at USC. In turn, the work under the USC AFOSR contract benefits Steve Taylor and Los Alamos seismic monitoring group by providing detailed analysis of regional propagation in the Tibetan Plateau, which is a key to understanding paths from Lop Nor to India and Pakistan. This exchange of information is expected to continue throughout this project. In addition, USC student Dan McNamara spent summers working with the LLNL seismic monitoring group and recently began a Post-doc there. George Randall left USC for a permanent position at Los Alamos, but continues to be a key advisor for the work of USC Ph.D. student, Philip Crotwell. Crotwell spent summer of 1997 working at Los Alamos and will be presenting collaborative work at the Fall 1997 AGU meeting in San Francisco.

New Discoveries, Inventions, or Patent Disclosures

None.